



Integrated biorefineries produce transportation fuels, chemicals, and power from diverse forms of regional biomass, promoting local and regional economic development and energy security. *Photos (clockwise from upper left): USDA/D854-1; Istock/6980819, 4556166, 8476990*

Integrated Biorefineries: Biofuels, Biopower, and Bioproducts

Achieving national energy and climate goals will require a large, economically viable, and environmentally sustainable U.S. bioindustry. The U.S. goal to produce 21 billion gallons of advanced biofuels by 2022 creates an urgent need to bridge the gap between promising research and commercial, large-scale production of advanced biofuels.

A crucial step in developing the U.S. bioindustry is to establish integrated biorefineries capable of efficiently converting a broad range of biomass feedstocks into affordable biofuels, biopower, and other bioproducts. Integrated biorefineries are similar to conventional refineries in that they produce a range of products to optimize both the use of the feedstock and production economics. Integrated biorefineries use novel technologies and diverse biomass feedstocks—requiring significant investments in research, development, and deployment to reduce costs and achieve competitiveness with fossil fuels.

The U.S. Energy Department's Bioenergy Technologies Office works in partnership with industry to develop, build, operate, and validate integrated biorefineries at

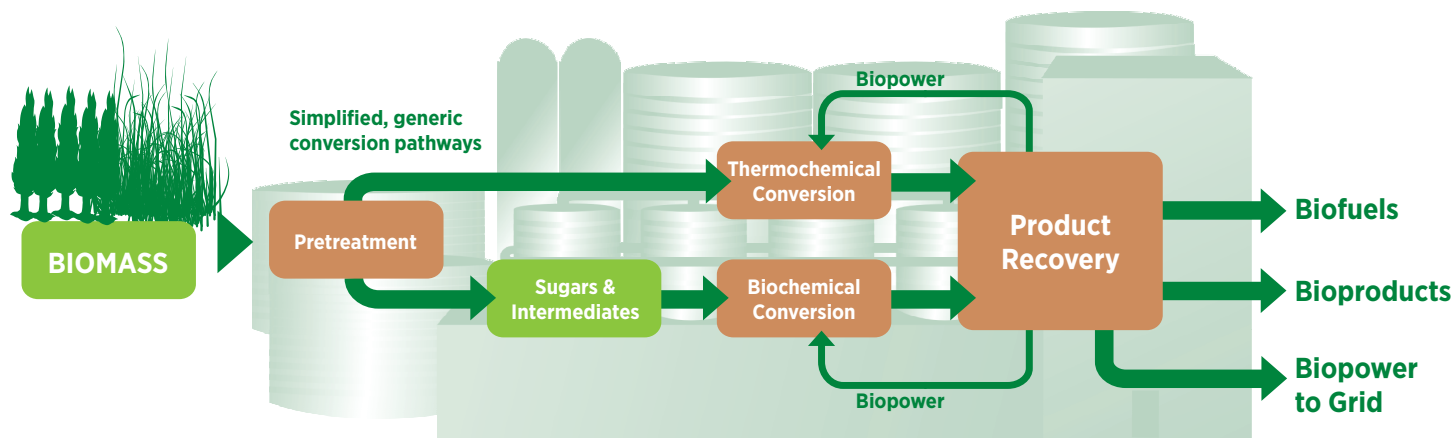
various scales (pilot, demonstration, and commercial). These projects are located around the country and cover a range of feedstocks and conversion technologies.

Federal support for first-of-a-kind integrated biorefineries can validate the costs and significantly reduce the technical and financial risks associated with new technology deployment, thus accelerating growth in the U.S. bioindustry. These investments support the national “all-of-the-above” strategy to develop domestic energy sources—reducing costs to consumers and improving energy security.

After decades of pioneering technological achievements and support from EERE, we expect the first commercial cellulosic ethanol biorefinery in U.S. history to fully come online this year. It will transform municipal solid waste and yard waste into renewable biofuels and clean energy.

*Testimony of Dr. David Danielson,
Assistant Secretary of EERE, March 14, 2013*

Integrated biorefineries use various conversion pathways.



Key Challenges:

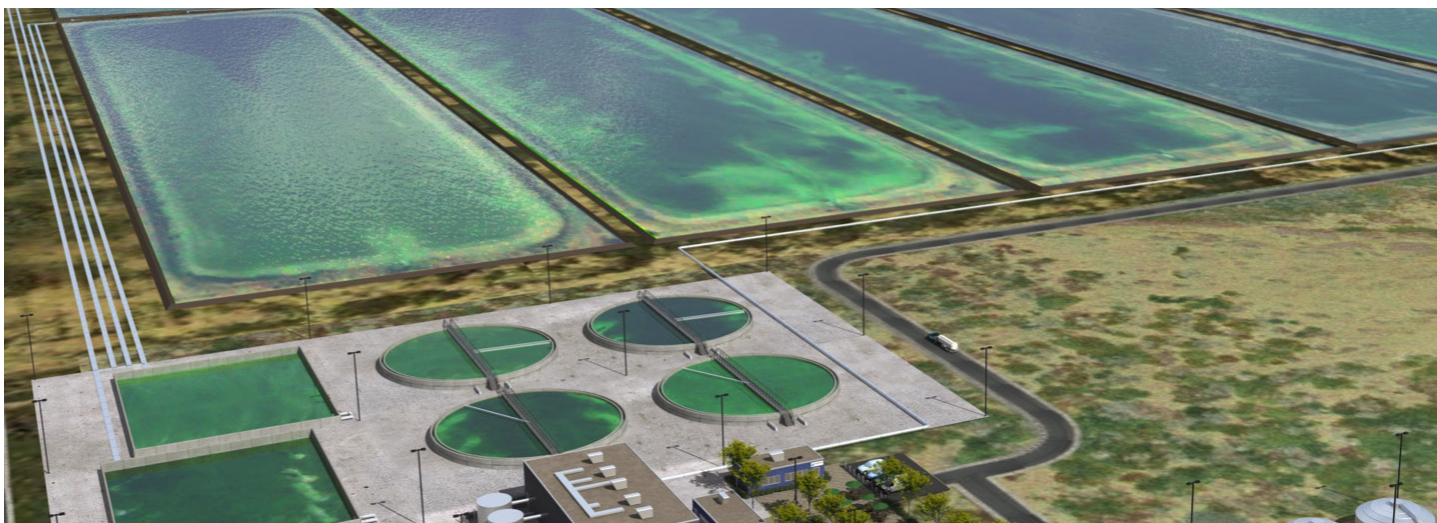
The U.S. bioindustry faces diverse challenges.

- Financing New Technologies:** Deployment and validation of new technologies and processes entail significant financial investment and technical risk. Financing of pilot-, demonstration-, and commercial-scale projects that use innovative technologies and diverse feedstocks is always challenging—but particularly in times of tight credit, as in the current market.
- Market and Economic Viability:** Integrated biorefineries must optimize the use of biomass to create a product mix that is matched to market demand and can compete with fossil fuels.
- Feedstock Diversity:** Biorefineries can use a variety of biomass feedstocks across the nation, capitalizing on each region's geography and climate. This diversity creates a challenge to developing replicable feedstock supply systems and specialized conversion technologies.
- Permitting:** To obtain proper permits, each biorefinery must establish community support and evaluate its potential environmental impacts. This process can be complicated as the specific conversion processes and feedstocks used in each biorefinery affect the facility's environmental footprint and impacts.
- Sustainability:** Economic, environmental, and social impacts must be carefully modeled and monitored on a life-cycle basis.
- Consistent Research, Development, and Demonstration (RD&D) Investments:** Government, academia, and industry have made significant investments in the development of feedstock and biorefinery technologies to foster growth in the nascent bioindustry. Many of these technologies remain in the early stages of development and will need ongoing, consistent support if the nation is to meet legislated production goals for advanced biofuels.



The Energy Department provides cost sharing for biorefinery projects to validate novel conversion processes and reduce the technical and financial risks to future investors.

Photo: NREL/01008



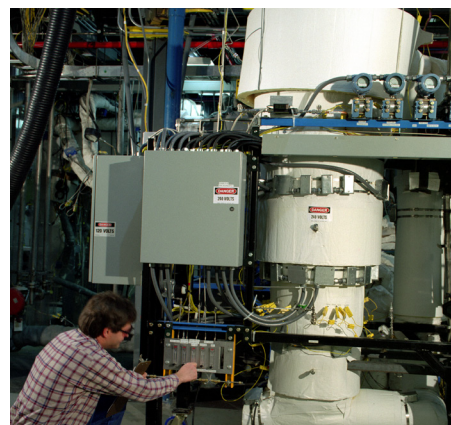
Sapphire Energy, one of six companies selected by DOE for a demonstration-scale biorefinery project, is building an integrated algae-to-energy farm in Columbus, New Mexico. (Artist's rendering courtesy of Sapphire Energy)

Integrated Biorefinery Deployment Activities:

The Bioenergy Technologies Office works through public-private, cost-sharing partnerships to address critical challenges in the deployment of technologies for integrated biorefineries. These partnerships undertake biorefinery projects to prove the viability of various feedstock and conversion pathways and reduce technical and financial risks. The projects typically follow a progression from pilot to demonstration scale and from demonstration to commercial scale. Each step in this progression enables validation of production performance at scale, paving the way for commercial readiness.

- **Pilot-Scale Projects:** Promising technologies are screened and validated through pilot-scale projects, which typically process at least one dry metric ton of feedstock per day. The American Recovery and Reinvestment Act (ARRA) enabled investments in 12 pilot-scale biorefinery projects.

- **Demonstration-Scale Projects:** After technologies have been validated at the pilot scale, they are scaled up to process a minimum of 50 dry metric tons of feedstock per day (representing 1/50 to 1/10 of commercial scale). The Energy Department has funded six demonstration-scale projects to further reduce technical and financial risks.
- **Commercial-Scale Integrated Biorefineries:** These projects process a minimum of 700 dry metric tons of biomass per day to produce cost-effective biofuels, biopower, and bioproducts at a small commercial scale. The Department and industry are currently cost-sharing construction of four commercial-scale integrated biorefineries (one using ARRA funding) with the cumulative capacity to produce more than 80 million gallons of biofuels per year.



Novel technologies to increase the efficiency and lower the cost of biomass conversion are validated at the pilot scale. Photo: NREL/09706

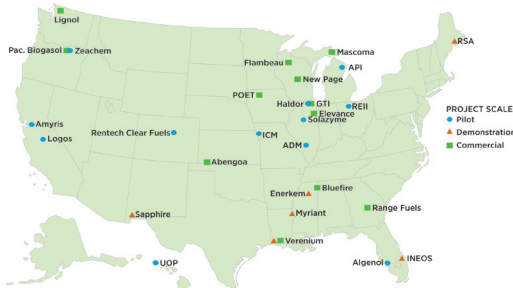


Commercial-scale biorefineries face many challenges in scaling up and integrating innovative technologies into profitable production systems. Photo: Rentech ClearFuels

Pilot-, Demonstration-, and Commercial-Scale Projects

Strategically locating biorefinery projects in different areas of the country promotes local and regional economic development and conversion technologies optimized for the biomass feedstocks in each region. Geographic diversity will also provide many areas of the nation with access to a domestic renewable energy supply as the private sector gains confidence in the technologies and scales up investment in new integrated biorefineries.

Integrated Biorefinery Project Locations



For the latest project information and details, please visit our website.

Integrated Biorefinery Projects Awarded DOE Funds

Project	Location	Scale	Conversion Technology
Abengoa	Hugoton, KS	Commercial	Biochemical
BlueFire Renewables Inc.	Fulton, MS	Commercial	Biochemical
Mascoma	Kinross, MI	Commercial	Biochemical
POET/DSM Advanced Biofuels, LLC	Emmetsburg, IA	Commercial	Biochemical
Verenium	Jennings, LA	Demo	Biochemical
Enerkem	Pontotoc, MS	Demo	Thermo - Gasification
INEOS Bio/New Planet Bioenergy	Vero Beach, FL	Demo	Hybrid
Myriant	Lake Providence, LA	Demo	Biochemical
Red Shield Acquisition, LLC (RSA)	Old Town, ME	Demo	Biochemical
Sapphire Energy, Inc.	Columbus, NM	Demo	Algae
Algenol Biofuels, Inc	Fort Myers, FL	Pilot	Algae
American Process, Inc. (API)	Alpena, MI	Pilot	Biochemical
Amyris, Inc.	Emeryville, CA	Pilot	Biochemical
Archer Daniels Midland (ADM)	Decatur, IL	Pilot	Biochemical
Haldor Topsoe, Inc.	Des Plaines, IL	Pilot	Thermo - Gasification
ICM, Inc.	St. Joseph, MO	Pilot	Biochemical
Logos/Edeniq Technologies	Visalia, CA	Pilot	Biochemical
Renewable Energy Institute International (REII)	Toledo, OH	Pilot	Thermo - Gasification
Rentech ClearFuels	Commerce City, CO	Pilot	Thermo - Gasification
Solazyme, Inc.	Peoria, IL	Pilot	Algae
UOP, LLC	Kapolei, HI	Pilot	Thermo - Pyrolysis
ZeaChem, Inc.	Boardman, OR	Pilot	Thermo - Pyrolysis
Gas Technology Institute (GTI)	Des Plaines, IL	Design Only	Thermo - Pyrolysis
Elevance	Newton, IA	Design Only	Chemical

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